

Lead and Zinc Mining in the Dubuque Area

by Greg A. Ludvigson and James A. Dockal



This small cave, along Catfish Creek valley, is an example of cavern development in an oxidized lead ore deposit and may have been one of Julien Dubuque's "Mines of Spain." Photo by Jim Dockal, University of North Carolina at Wilmington.

Historical Significance: While traversing Iowa's rich agricultural landscapes, modern travelers see little to remind them that the state's earliest European explorers were attracted here by metallic mineral wealth. The first written accounts by French travelers in the Upper Mississippi Valley indicate that Indian fur trappers working with French *voyageurs* were engaged in primitive lead mining and smelting activities in this region before the year 1650. By 1682 the lead deposits of the Upper Mississippi Valley were known in Europe through the writing of Nicholas Perrot, and by the end of the century, French and English maps of North America clearly showed lead mines at the present sites of Dubuque, Iowa and Galena, Illinois. By 1788, a charismatic and energetic French-Canadian trader named Julien Dubuque secured exclusive franchise from the Sac and Fox Indian tribes to all mines west of the Mississippi River. In 1796, when this grant was confirmed by the Spanish governor of Louisiana, Julien Dubuque had succeeded in establishing a monopoly controlling the smelting and shipping of lead from the region. Until his death in 1810, Dubuque operated the "Mines of Spain" from Kettle Chief's village near the mouth of Catfish Creek, a few miles south of the present city of Dubuque. Ridden with debt, Dubuque lost financial control over the "Mines of Spain" shortly before he died, and the enterprise abruptly collapsed following his death as his creditors were unable to sustain his good relationships with their Native American hosts. Lead-mining rights in Iowa remained in a legal turmoil that lasted until 1853, when the United States Supreme Court issued a landmark decision on the ownership of the Dubuque area mines, disallowing claims based on Julien Dubuque's Spanish land grants.



The timber structure in this 1899 photo is built over the top of a vertical zinc mine shaft at Dubuque, Iowa. This structure houses the pulley and engine system for hoisting and dumping loaded buckets of ore. The ore was graded and hand-sorted into boxes (under open roof). *Photo courtesy, The University of Iowa Calvin Collection.*

Thus began the colorful mining history of Iowa's portion of the Upper Mississippi Valley Zinc-Lead District. The mining district, a major producer of zinc and lead ores throughout much of this country's history, covers portions of northeast Iowa, southwest Wisconsin, and northwest Illinois. Commercial mining ventures in Iowa have taken place in Dubuque, Clayton, Allamakee, Jackson, Clinton, and Jones counties. The early development of the district was spurred by the need for metallic lead, used chiefly for making lead shot. Lead production from the Upper Mississippi Valley District peaked in 1848, shortly before the gold rush to California drew many miners west in search of greater riches. The economic life of the district was extended indefinitely when the commercial production of metallic zinc began in 1860. With its reserves greatly exceeding those of lead, zinc production from the district peaked during World War I. The mining of base metals historically has been an unstable business, and zinc production from the Upper Mississippi Valley District has waxed and waned primarily in response to

economic rather than resource controls. The mines of Dubuque area were closed in 1910, although a brief attempt was made to revive the industry in the early 1950s. Over 300 years of continuous mining activity in the Upper Mississippi Valley was broken on October 1, 1979, with the closing of the district's last operating mine at Shullsburg, Wisconsin. While it is clear that large quantities of ore remain to be extracted from the region, it is unclear if and when the enterprise will again be considered a profitable venture.

Why the Deposits are There: The zinc-lead deposits of the Dubuque area and the Upper Mississippi Valley are part of an important class of metallic, hydrothermal (formed by hot water) ore deposits that are referred to collectively as Mississippi-Valley-Type (MVT) deposits. Hydrothermal deposits are known to be derived from hot vapors escaping from cooling igneous magmas, typically formed in mountain-building regions. MVT deposits, however, occur in areas of relatively flat-lying sedimentary rocks in the continental interior, distant from any possible igneous sources. The term "Mississippi-Valley-Type" deposit was coined because several of these ore fields form major mining districts within the drainage basin of the Mississippi River. In addition to the mining district located in the Upper Mississippi Valley region, major MVT ore fields are located in southeast Missouri (Viburnum Trend District), southwest Missouri (Joplin District), Illinois-Kentucky (Cave-in-Rock Fluorspar District), and central Tennessee (Mascot-Jefferson City District). All of these mining districts either presently are or have been major producers of industrial base metals in the United States.

In addition to their significant economic importance, MVT deposits have remained a challenging topic for geological research for well over a century. Though a great volume of geologic literature is devoted to observations and hypotheses on the origins of MVT deposits, many aspects of their occurrence remain controversial. Such academic pursuits are important because mineral-exploration programs are based on the geologist's conception of ore genesis.

For example, in the 1890s when geologists from the Iowa Geological Survey routinely visited operating and abandoned zinc and lead mines in northeast Iowa, the prevailing theory was that the ore deposits had been concentrated by descending groundwater which dissolved minerals from the shallow bedrock and deposited them at greater depths. For several decades this misconception prevented exploration for ore deposits in areas where shale units form the bedrock surface, as the impermeability of shale was presumed to have retarded the necessary infiltration of groundwater.

Early during the Second World War, the urgent need for strategic mineral reserves spurred a collective effort by the United States Geological Survey (USGS) and the state geological surveys of Iowa, Illinois, and Wisconsin to undertake a systematic reappraisal of the geology of the Upper Mississippi Valley Zinc-Lead District. This effort spanned more than a decade and included federally sponsored exploration drilling in all three states. The drilling program led to the discovery of the two largest ore deposits ever mined in the district. In 1959, with the publication of USGS Professional Paper 309, the cumulative results of over a century of geologic research on the zinc-lead ore deposits of

the Upper Mississippi Valley were described in detail. To this date, the publication remains the single most authoritative reference on the Upper Mississippi Valley District.

During the last two decades, the pace of research on MVT deposits has accelerated. Analytical precision in the laboratory has improved. Measurements of minute variations in isotopic ratios of component elements as well as analyses of microscopic bubbles trapped during the growth of MVT ore minerals have yielded much valuable information about the sources of the minerals and the hot waters from which they were precipitated. While technical disagreements among researchers still remain, a general consensus has emerged: the component elements of MVT ore deposits are derived from marine sedimentary rocks, and are carried upward in solution and deposited by hot (80 to 200 degrees C) saline brines. These brines are similar in many respects to so-called "oilfield brines," and in fact many researchers see a link between the formation of MVT ores and petroleum deposits. Modern MVT exploration geologists are attempting to interpret the histories of past migrations of hot subsurface water through portions of the continental interior, migrations which occurred hundreds of millions of years ago.

The metallic lead and zinc in MVT ore deposits are chemically bonded with sulfur to form sulfide minerals. The ore deposits were formed as sulfide mineral crystals precipitated from the hot brines on the walls of open, vertical fractures (cracks) in carbonate rocks below the surface. As crystal growth continued, all open space was filled, leaving a network of vertical veins of sulfide minerals in the rocks.

These sulfide mineral deposits are chemically unstable in the presence of atmospheric oxygen and water, and rapidly decay (oxidize) when the local water table is lowered below them. During the geologically recent excavation of the Mississippi River gorge, water tables in the adjacent river bluffs were lowered, and the sulfide veins in the Dubuque area were modified in an unusual fashion. No longer protected from oxidation, sulfide deposits above the water table were dissolved by infiltrating groundwater, and a network of natural caverns or "crevices" were formed along the older network of vertical veins. These caverns were floored by residual debris consisting of materials known to the miners as "ocher" (iron oxide formed by the decay of pyrite or iron disulfide, also known as "fools gold"), "drybone" (zinc oxides and carbonates formed by the decay of zinc sulfide), and loose encrusted crystals of galena-lead sulfide. Because lead sulfide oxidizes far more slowly than the accompanying iron and zinc sulfides, the soft debris which floored the "crevices" was filled with scattered crystals of partially dissolved galena.

When the earliest underground mining began in the Dubuque area, the "crevices" had already been in existence for tens of thousands of years, long enough to be partially filled with speleothems-the flowstone formations that commonly decorate natural cavern systems in carbonate rocks. The soft fill at the base of the open crevices was easily mined, and the galena was separated from the enclosing ochereous debris by washing and hand sorting. As excavations in the crevices extended to deeper levels and down to the water table, unoxidized sphalerite (zinc sulfide, known to the miners as "blackjack") ores were encountered. Commercial exploitation of zinc-sulfide ores was delayed until the

latter half of the 19th century, when the development of steam-engine powered pumps enabled mining to take place below the water table.

Modern Impacts of Past Mining Activity: A search of the literature and the scant records pertaining to the mines at Dubuque indicates that approximately 500 mining operations were established after the year 1820. No written records are preserved for many of these operations, and consequently there is a wide range of estimates concerning the actual number and extent of these mining enterprises. Since the late 1950's, members of the Iowa Grotto Chapter of the National Speleological Society have examined approximately 200 of these mines, and 90 actually have been surveyed. It is estimated that miners dug roughly ninety miles of tunnels, sunk between 700 and 2,000 shafts ranging from 20 to 250 feet in depth, and excavated numerous shallow exploration pits.

As a general rule, production records were not kept, mines were not surveyed, nor were mine locations plotted. Only a handful of legal documents exist that pertain directly to mining activity. These record only mine ownership and a legal description of the tract on which the mine was located. Furthermore, there was no legislation establishing procedures for closing and abandoning mines. When a mine closed, the miners simply left the tunnels and shafts, and frequently left their tools, ore carts, ropes, and explosives.

The abandonment of surface workings is more difficult to evaluate because of exposure to weather and urban development. Even there, however, evidence suggests that the miners left without any attempt to close the tunnels, cap or fill the shafts, and remove surface equipment. With few exceptions, the abandoned shafts in the Dubuque mining area were left open until the timbering at their tops collapsed, partially filling the shaft. The depressions or "mineral holes" were later used as dumps for old fences, cars, garbage, or animal carcasses. With urban development in the area, these were later bulldozed over, and houses and streets were constructed.

It is no wonder that Dubuque, with its estimated 700 to 2,000 abandoned mine shafts, occasionally experiences the loss of a front yard or collapse of a street. A land-surface collapse along Hill Street in 1983 illustrates the difficulty in precisely locating old underground mine workings and the uncertainty in predicting areas of possible mine-related subsidence (see photo). Published records are only accurate enough to establish the close proximity of this recent collapse to the abandoned workings of the Avenue Top Mine, a mine opened in 1875, and now inaccessible for underground inspection and evaluation.



This road collapse along Hill Street in Dubuque occurred on November 12, 1983, and probably was caused by sinking of surface materials into the abandoned workings of the Avenue Top Mine. *Photo by Steve Gustafson, Dubuque Telegraph Herald. Reprinted with permission.*

The often-used practice of filling collapsed shafts with sand, gravel, and earthen fill generally has proven inadequate. Many of the shafts were driven below the water table, and most connect extensive networks of tunnels. Loose fill only hides the problem temporarily. With time, settling and movement of fill into the tunnels causes the column of fill to gradually descend in the shaft. This will lead to slow subsidence at the surface, or even worse, hollow space may develop below the surface which later can suddenly collapse. In either case, damage may occur to overlying structures at the surface, and in the event of a sudden collapse of unsupported fill, catastrophic damage may result. While an understanding of subsurface geologic conditions is always important for the engineering design of structures, this need is especially critical in areas of past underground mining.

Inventories of underground lead and zinc mines in Iowa were conducted by the Iowa Geological Survey (IGS) during the 1890s, when many of these operations were either active or recently abandoned. Unfortunately, to this day, maps published in the IGS Annual Report Volume 10 on Dubuque County (1899), and in later USGS reports published in the 1950s and 1960s, are the only complete descriptions available for locating areas of potential hazard from underground mine subsidence in Dubuque. These maps can only establish the approximate areas of past mine workings in relation to modern landmarks. Fortunately, the ore deposits and subsequent underground workings in the Dubuque area followed long, narrow pathways of limited width.

The occurrence of mine-related subsidence in the Dubuque area need not necessarily pose a threat to modern structures-if subsurface conditions are properly evaluated before construction. Any major construction projects in areas suspected to be underlain by abandoned mines should be preceded by engineering foundation studies. Thus, the legacy of metallic mining in the Dubuque area includes a long, colorful local history, as well as a poorly defined subsidence hazard associated with old, concealed underground mines whose precise locations are not known.

NOTE: The Mines of Spain is the name given to a 1,260-acre tract of Julien Dubuque's original 290 square-mile Spanish Land Grant. This property, now in public ownership, is along the Mississippi River bluffs south of Dubuque.

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